DRAFT INTERIM SPECIFICATION FOR TRIGONOMETRIC LEVELING

Second Order, Class II

NETWORK GEOMETRY

Same as in Standards and Specification for Geodetic Control Networks, Federal Geodetic Control Committee, 1984, page 3-6.

INSTRUMENTATION

Electronic Theodolite

Zenith Distance-standard deviation $\pm$ 0.5 seconds

Electronic Distance Measuring Instrument

Distance- Standard deviation $\pm$ 5 mm 3 ppm or better

Targets

Must be designed so that the zenith distance and EDMI slope distance are measured to or can be reduced to the same point and have a well defined pointing area for zenith distance, preferably, a wedge shaped light background between two dark areas.

Target Poles

Each set of poles should be constructed of the same material.

Must be one piece with a durable flat footplate.

Should be 2-2.5 meters in length.

Each set should be the same length to within 1 mm.

Must have a leveling bubble of 20-minute sensitivity or better.

Must have braces to provide good stability.

Should have a pointing device capable of keeping the target face perpendicular to the line of sight to the instrument.

Barometer

Accurate to $\pm$ 0.5 inches.

Thermometer

Accurate to $\pm$ 0.5 degrees Centigrade.

Turning Points

A turning point consisting of a steel turning pin with a driving cap should be utilized. If a steel pin cannot be driven, then a turning plate ("turtle") weighing at least 7 kg should be substituted. In situations allowing neither turning pins nor turning plates (sandy or marshy soils), a long wooden stake with double-headed nail should be driven to a firm depth.

<u>Tripod</u>

Fixed legs that will provide good stability.

CALIBRATION

<u>EDMI</u>

Should be calibrated, at least annually, over an established calibration base line.

<u>Electronic Theodolite</u>

Vertical Index Error to be checked once a day.

Circular instrument leveling bubble (bullseye) to be kept in good adjustment.

<u>Targets and Poles</u>

Leveling rod bubble verticality maintained to within 10'.

Leveling rod bubbles to be checked daily or at any time a problem may be suspected.

Each target should be checked, at least annually, for reflector offset constraints. Reflector offset constants should be as close to equal as possible. If they are not equal, then data collector software should be able to distinguish between them and apply the correct offset to the slope distance for respective target.

FIELD PROCEDURES

<u>Minimal Observation Method</u>

Backsight - circle left (BSCL)
Foresight - circle left (FSCL)
Foresight - circle right (FSCR)
Backsight - circle right (BSCR)

Backsight - circle left (BSCL)
Foresight - circle left (FSCL)
Foresight - circle right (FSCR)
Backsight - circle right (BSCR)

Uncorrected zenith distance (ZD) and slope distance measured at each pointing. Corrected ZDs will be computed and slope distances will be corrected for refractive index and offsets. A standard curvature and refraction correction will be applied to each instrument to target d.e. prior to computing setup d.e. . Computations will result in two independent d.e.s for each setup. The mean of these will be the final setup d.e. .

Section Running

Double Run (DR) or a Single Run Modified Double Simultaneous (SRMDS) where two independent differences of elevation are determined at each setup.

May single run using SRMDS, if line length between network control points is less than 10 km.

At the minimum must use SRMDS; must double run spur lines; must double run 10 percent of all single run leveling.

Difference of Backward and Forward Sight Lengths

Difference of backward and forward sight lengths never to exceed 10 meters per setup and 10 meters per section.

Maximum Sight Length

Maximum sight length never to exceed 70 meters.

Minimum Ground Clearance

Lines of sight to backsight and foresight should be kept as parallel to ground as possible so as to parallel isothermal layers. Minimum ground clearance of line of sight 1.0 meter.

Even Number of Setups

An even number of setups will assure that the same target will be observed at both the starting and ending benchmarks. Any difference in height of target poles affecting section d.e. will be eliminated.

Maximum Section Misclosure

Second Order Class II- 8mm/D where D is the shortest length of section (one way) in km.

Maximum Loop Misclosure

Second Order Class II- 8mm/E where E is the perimeter of the loop in km.

Single-run Methods

Reverse direction of single runs every other day.

Trigonometric Leveling

A precision check will be performed between the two setup differences of elevations computed from the observations.

The difference between the two d.e.s for one setup not to exceed 1.4 mm.

Double run leveling may always be used but SRMDS may be used only where it can be evaluated by loop closures or new-old comparisons. Rods must be leap-frogged between setups (alternate setup method). The date, beginning and ending times, cloud coverage, air temperature (to nearest degree), temperature scale, barometric pressure (to $\pm$ 0.5 inches HG), pressure units, and average wind speed should be recorded for each section, plus any changes in the date, instrumentation, observer, or time zone.

OFFICE PROCEDURES

Second Order, Class II

Section Misclosures

(backward and forward) Algebraic sum of all corrected section misclosure of a leveling line not to exceed 8mm/D.

Section misclosure not to exceed 8mm/E.

Loop Misclosures

Algebraic sum of all corrected misclosure not to exceed 8mm$\sqrt{F}$.

Loop misclosure not to exceed 8mm$\sqrt{F}$.

(D = shortest length of section (one way) in km)
(E = shortest one-way length of section in km)
(F = length of loop in km)

The normalized residuals from a minimally constrained least squares adjustment will be checked for blunders. The observations weights will be checked by inspecting the post adjustment estimate of the variance of unit weight. Elevation difference standard errors computed by error propagation in a correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use models that account for:

Gravity effect or orthometric correction
Earth tides and magnetic field
Crustal motion

Refraction – (may be accounted for, at some later date, after more data is available for analysis)